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WATER QUALITY OF THE TISZA RIVER AT SZOLNOK IN THE PERIOD 1970—1988

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Abstract

A process of water purification is characteristic for the second biggest Hungarian river in the stretch between the mouth of the Sajó river and Szolnok. Because of the considerable water consumption of Szolnok for industrial purposes and drinking-water supply, the water quality and its longterm changes are of outmost importance. Our analysis is based on the evaluation of results obtained in the studies of water samples collected weekly from the Tisza reach at Szolnok (335,4 river km, Fig. 1) in the period 1970—1988. In order to obtain sufficiently detailed information on the water quality the most important 27 water quality parameters have been considered in the present study.

The changes observed in the annual maximal, minimal and mean values of several parameters in the period between 1970 and 1988 are shown in Figs 2—5. The changes in the water quality reflected by the mean values of the quality parameters were not considerable, altogether deterioration of water quality was observed (Table 1), which is proven by the increase in the average concentrations in most of the parameters.

The direction and extent of the changes were determined for the periods 1970—1978 and 1979—1988 by means of regression analysis (Table 1). It was found that a considerable deterioration of water quality took place in the 70s. Among the parameters studied 52% showed an improved or unchanged water quality, 22% indicated slight and 22% — considerable deterioration between 1979 and 1988 (Table 2).

The quality of water in the Tisza met the I. class requirements when used for industrial and irrigation purposes during the whole period studied (Table 3). From 1976 on it corresponded only to II. class in covering the needs of fishery or drinking-water supply, and in this field a further deterioration of water quality is to be expected.

Introduction

The water of the Tisza river reaching the territory of Hungary is very clean, all water quality parameters meet the requirements for I. class water quality. However, the river water is influenced unfavourably by its tributaries, in the first place by the polluting materials carried by the Szamos and Sajó rivers. A process of water purification is characteristic for the Tisza stretch from the mouth of Sajó to the reach at Szolnok, where our studies have been carried out (VIGH 1983).

Since the consumption of water for industrial purposes and drinking-water supply in Szolnok is significant, the water quality and its long-term changes are of a particular importance. The changes have been followed in our studies on the basis of data obtained for the reach at Szolnok (335,4 river km) above the mouth of the

Zagyva river (Fig. 1). Samples have been collected in this reach practically every week (52 samples/year) between 1970 and 1988. In our analysis data on 27 important, almost exclusively macro-component parameters were evaluated.

ANDERSON—ZAGORSKI (1968) studied 3 water quality parameters (dissolved O_2, BOD_5 and coliform bacteria) in a reach of the Passaic river between 1955 and 1968 assuming linearity of the trends. EDWARDS—THORNES (1973) studied the tendencies in 8 water quality parameters on the basis of weekly measurements in the Staur river during a twenty-year period (1950—1970). HORVÁTH—PANNONHALMI—VÁRDAY (1981) compared the relation between concentration and massflow in respect to four parameters (COD_k, NH_4, NO_3 and PO_4) for the whole stretch of the Danube on the territory of Hungary during two periods (1968—1972 and 1973—1978). ROTSCHEIN (1981) evaluated a series of COD_p measurements carried out on water samples from the Danube between 1950 and 1978 in a function of time. STEGMAN (1976) established trend equations for 9 parameters measured in Oker between 1965 and 1974.

HOCK (1981) determined the trends for a ten-year series of 6 water quality parameters measured in 25 incoming and 3 outgoing reaches of Hungarian border rivers. In 1983 he developed a water quality model for prediction of the trends in water quality changes, the results of which were demonstrated on the data measured between 1970 and 1979 in 11 border reaches of the Tisza river system (Tisza, Szamos, Bodrog, Sajó, Bódva, Hernád, Fehér-Körös, Fekete-Körös, Sebes-Körös, Berettyó, Maros). From 11 border reaches studied, in 9 cases for the concentration of PO_4-ion 8,0—18%, for ammonium-ion in 8 rivers 3,0—12,7%, for nitrate-ion as well in 8 border rivers 3,5—10,6%, for dissolved O_2 in 7 rivers 0,8—2,9%, for BOD_5 in 3 rivers 2,5—8,5% annual water quality deterioration was established. Among the six border rivers from the water-shed area of the Tisza above Szolnok the most significant water quality deterioration occurred in the Szamos.

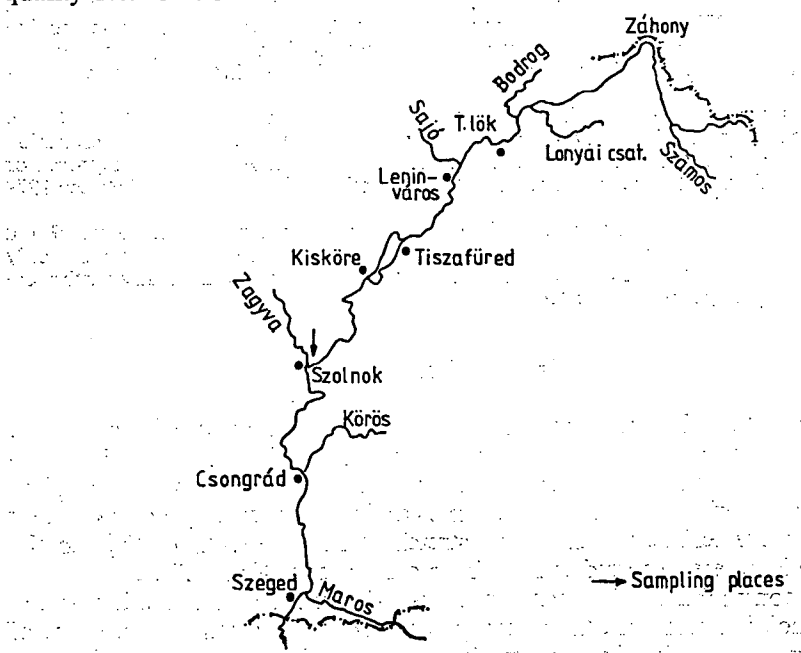

Fig. 1. The stretch of the Tisza river on the territory of Hungary

Materials and Methods

In the evaluation of the water quality of the Tisza river were used the results of measurements carried out on samples taken from the reach at Szolnok (above the influx of the Zagyva river, 335,4 river km). This reach belongs to the national basic surface water network, where the water tests are carried out weekly (number of samples: 52/year). The water quality parameters were measured in the samples in the Laboratory of KÖTI—KÖVIZIG (Directorate of Environmental and Water Conservancy of the Central Tisza Region) in Szolnok according to the effective regulations and CMEA methodology.

Results and Discussion

Concentration changes in function of time

It is important to emphasize that annual changes in water quality are influenced to a considerable extent not only by the varying pollution load but by the hydrological and meteorological factors as well.

One of the most important factors modifying the water quality — the water output, varied significantly from year to year (Fig. 2). The maxima often exceeded many times the mean value.

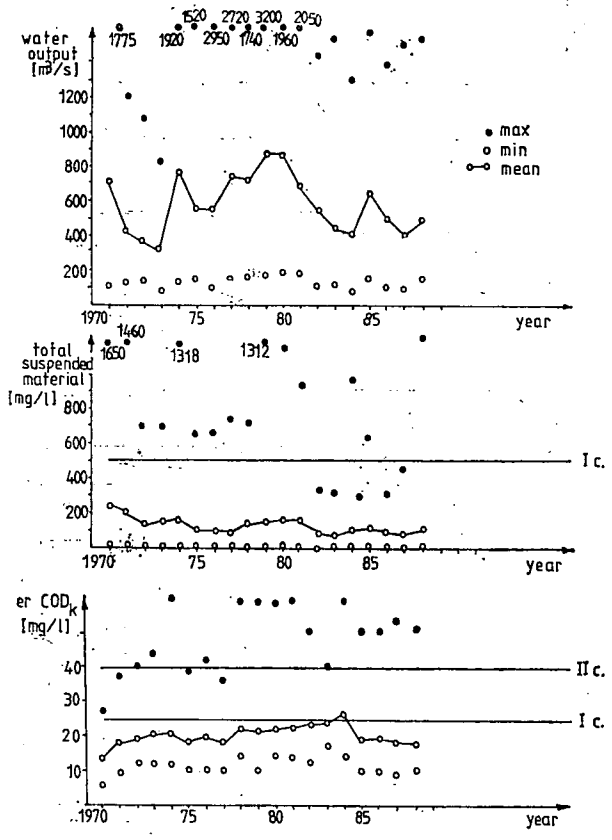

Fig. 2. Changes in water output, total suspended matter and COD_k concentrations in the Tisza (Szolnok)

The total concentration of the suspended mater depended strongly on the river flow. In all cases maximal values were measured during the periods of high water, reaching occasionally extremely high values, exceeding 1000 mg/l. Minimal values between 1 and 10 mg/l coincided with the summer periods of low water (Fig. 2).

The annual maxima of COD measured in the original samples by the chromate method, appeared together with the maxima in suspended mater concentrations (Fig. 2). The mean values were close to or even in one year exceeded the I. class limit value.

The changes in BOD_5 concentration values in different years were less pronounced than those of COD.

The concentration of dissolved O_2 (and the oxygen saturation) tended to decrease in the course of the 19 years of observation, however, since 1978 the decrease stopped (Fig. 3). The oxygen content of water was always sufficient for supporting the life functions of aquatic organisms. The minimal values fell between the limit values for

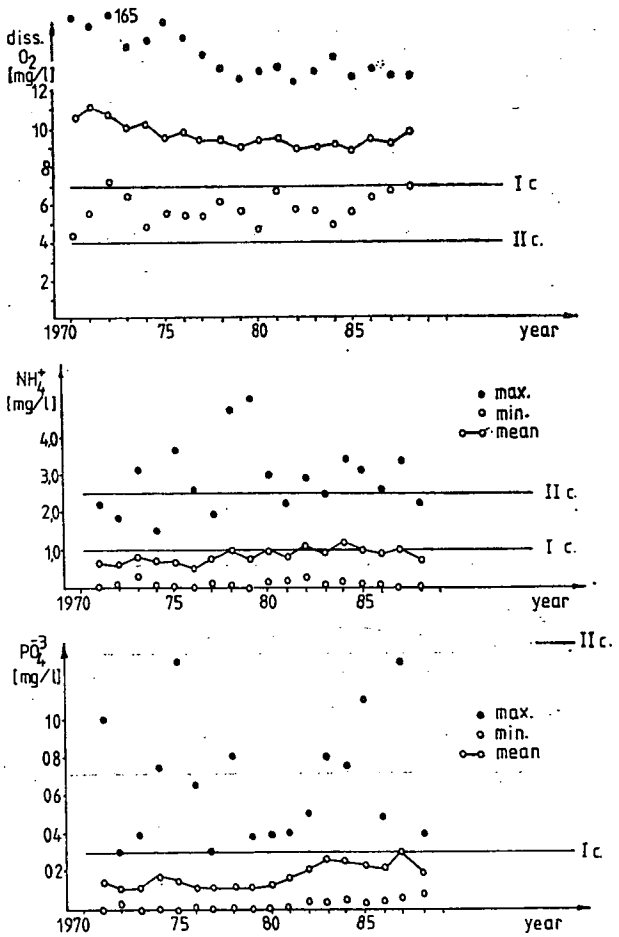

Fig. 3. Changes in concentration values of dissolved oxygen, ammonium-ion and phosphate-ion in the Tisza (Szolnok)

I. and II. class, and were observed in the summer-autumn periods of low water. The trend in the changes of this parameter is in accordance with the increase of the organic mater content in the water.

Among plant nutrients the concentration of ammonium-ion steadily increased (Fig. 3). In the last years its mean values exceeded the I. class limit value. Maximal values were observed always in winter periods characterized by low water temperature (WAIJANDT 1987). Minimal values were registered in warm summer periods. The values of this parameters varied in a relatively wide range from year to year.

The mean concentrations of nitrite-ion fell in the II. class water quality range. Till 1980 its values increased, after which they decreased to a similar extent.

The concentration of nitrate-ion hardly changed in the studied period, and its mean values never exceeded 9 mg/l. The maximal values were lower than the I. class limit values (WAIJANDT 1988).

The measurements of total nitrogen content started in 1975. The values showed a strongly decreasing tendency. The maxima coincided with the periods of the maximal concentration of suspended mater. Since 1979 the changes in the mean values showed a great similarity to the changes in the average water output.

The phosphate-ion content of the Tisza increased significantly (Fig. 3).

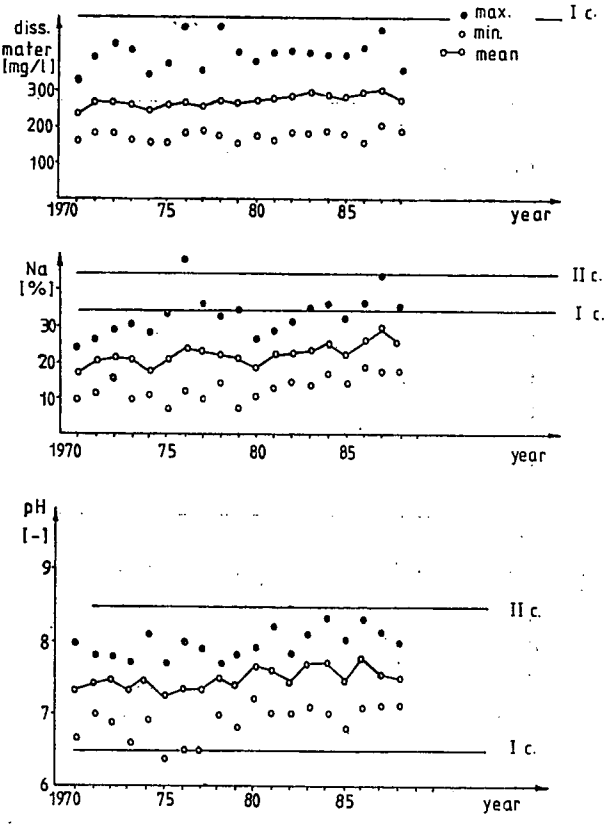

Fig. 4. Changes in the concentration of total dissolved matter, Na% and pH values in the Tisza (Szolnok)

This increase can not be attributed slowly to the application of phosphate artificial fertilizers in the agriculture, since the phosphate concentration of communal waste-waters is as well significant (WAIJANDT 1988).

The changes in the mean concentration of the total phosphorus did not follow in magnitude the increase in the phosphate-ion concentration. The maximal values are remarkably high and usually coincided in time with the suspended matter maxima.

Among the mineral components the total mineral salts are included in good approximation in the total dissolved matter. The values of this parameter are considered to be favourable since even the maximal values are within the I. class range (Fig. 4).

Considerable changes in unfavourable direction were observed in the Na% values (Fig. 4). The increase in this parameter is probably related to the raise in chloride- and sulphate-ion concentrations. In the last years during lasting periods of low water the maximal values fell already into II. class range. The source of the increased Na load is the industry and partially the thermal waters in the Tisza watershed area.

The total hardness and alkalinity of the Tisza water did not change noticably in the last 19 years.

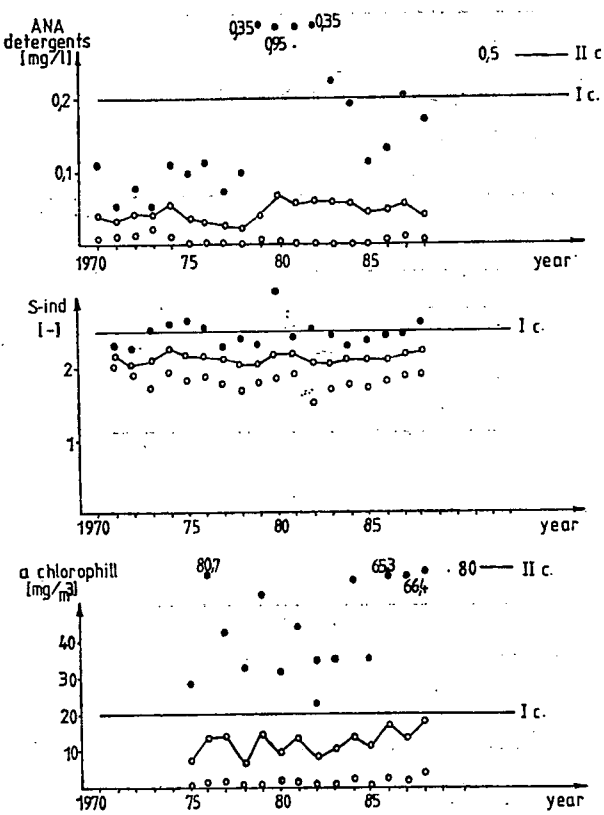

Fig. 5. Changes in the concentrations of anion active detergents, a-chlorophill and saprobity-index values in the Tisza (Szolnok)

The chloride- and sulphate-ion concentrations showed a slight increase but remained in the favourable lower half of the I. class range.

The pH values were in the I. class range of 6,5—8,5, except for one case. Both the mean and maximal values showed an increasing tendency (Fig. 4).

Phenols originating mainly from antropogen sources showed an increase in the last few years.

The concentration of anion active detergents is favourably low. The mean concentrations did not increase since 1980. However, occasionally strikingly high maxima were detected, which tended to be less pronounced in the last years (Fig. 5).

The apolar mineral oils (UV-oils) have been determined photometrically in the UV spectral region (MSZ—12750/23—76). According to some oppinions, besides the oils other organic substances absorb as well at the wave-length used in our measurements. For this reason the measured values contain certain positive error of unknown magnitude. The concentration values showed a definite increase.

Among the biological components the values of S-index (Saprobity index) practically did not change, except for insignificant variations (Fig. 5). The changes in S-index did not follow the increase in the organic matter content.

The increase in the mean value of a-chlorophill followed with considerable variations the increase in the concentrations of ammonium- and phosphate-ion, which being plant nutrients are easily taken up by the algae. The maximal values increased significantly in the last years (Fig. 5). and were measured in warm summer periods of low water.

Tendencies in water quality changes

In a series of water quality data measured during a comparatively long period components reflecting long-term trends, periodicity and randomly occurring changes can be distinguished (KÖVES—PÁRNICZKY 1986).

In the present evaluation we did not look for the causes of water quality changes and did not estimate the individual effects of different modifying factors (water output, loading, meteorological circumstances, etc.). For different consumers the resulting water quality is of a primary importance. It can be seen from the figures that the changes in the mean values are comparatively small. For this reason assuming a linear trend, the regression lines were calculated for the mean values obtained in the periods 1970—1978 and 1979—1988. With their help the annual changes were obtained and are summarized in Table 1 in percent and concentration values (because of the importance of water output, the corresponding data for this parameter are given as well).

Among the 27 parameters studied — taking into consideration the mean values obtained in the two periods — altogether in 6 cases an improvement of water quality was observed (Table 1). Thus during the whole 19-year period a deterioration of water quality occurred.

If the two periods — 1970—1978 and 1978—1988 — are considered separately, it can be seen that a considerable water quality deterioration took place in the 70s. In this period the organic mater load increased and the dissolved oxygen and oxygen saturation decreased (Because of the significant increase in COD_{sp} values in 1978—79, a decreasing tendency was obtained for both periods). The concentrations of ammonium-, nitrite- and nitrate-ions considerably increased.

In 1979—1988 period a significant increase was observed in Na% and pH values, concentrations of phosphate-ion, phenols and a-chlorophill. However, the

absolute increase of phenol concentration is negligibly small. During this period among the parameters studied 52% showed improved or unchanged water quality, 22% indicated small and 22% — a considerable deterioration (Table 2). The absolute value of the change observed for the only substantially deteriorated parameter — dissolved Mn — is insignificant (Table 1).

Changes in water quality according to the specificity of consumer

Since 1978 the biological stability of water determined on the basis of 17 frequently measured components according to the regulations (MSZ—10—172/3—85) changes steadily from I. to II. class (Table 3). The mineral components important when water is used for industrial and irrigation purposes did not change significantly, as described above. In these two fields of consumption the Tisza water was of I.

Table 1. *Measure of water quality changes in the Tisza reach at Szolnok (1970—1988)*

Component	1970—78 change %/year		1979—1988 change mg/l/year	1970—78 Mean value mg/l	1979—1988 Mean value mg/l
Water output	4,0	−7,1	−41 (m^3/s)	568	580
Total suspended mater	−8,4	−6,9	−7,5	147	108
Dissolved Fe	−3,2	−2,4	−2,4	0,22	0,10
Dissolved Mn	−8,8	9,4	0,007	0,03	0,078
Er COD_{sp}	−0,1*	−0,6	−0,04	5,97	6,68
Er COD_k	1,2*	−2,5	−0,53	19,6	21,4
BOD_5	−1,8	−2,2	−0,10	4,62	4,47
Dissolved O_2	−1,8	0,4	0,034	10,1	9,24
O_2 saturation	1,9	0,4	0,37(%)	91,4	82,9
Total alkalinity	−1,0	−0,7	−0,02	2,62	2,51
Total hardness	−1,0	−0,7	−0,68	92,5	90,5
Cl^--ion	0,3	1,5	0,5	30,5	33,4
SO_4-ion	2,5	1,3	0,7	47,6	52,2
Total dissolved matter	0,8	0,7	2,0	257	282
sp. conductivity	0,8	0,6	2,6 (uS/cm)	361	400
Na% value	2,4	3,2	0,7 (%)	20,6	23,2
pH value**	−0,8	3,4	0,007 (−)	7,38	7,57
NH_4-ion	3,7	0,6	0,006	0,74	0,95
NO_2-ion	11,5	−9,5	−0,021	0,20	0,22
NO_3-ion	4,1	−1,0	−0,08	7,2	7,6
Total N	—	−7,0	−0,31	—	4,4
PO_4-ion	−3,5*	6,0	0,012	0,13	0,21
Total P	—	−3,7	−0,011	—	0,29
Phenols	—	5,3	0,0002	—	0,004
ANA detergents	−5,6	−2,0	0,001	0,034	0,050
UV oils	—	6,5	0,018	—	0,28
S-index	−0,4	0,2	0,005 (−)	2,12	2,11
a-chlorophill	—	4,6	0,60 (mg/m^3)	—	13,0

* 1971—1978

** calculation of the measure of change: change/2,0 (the I. class range 8,5—6,5 = 2,0)

class during the whole period studied and in the near future its classification is not expected to change.

The majority of the parameters important from the point of view of fishery and drinking-water supply showed unfavourable changes. Consequently from 1976 on

Table 2. *Evaluation of water quality changes in the period 1979—1988 on the basis of MSZ 10—172/1—83*

1. Practically unchanged or improving components (n = 14, 51,9%)

total suspended matter	NO_2-ion
dissolved Fe	NO_3-ion
$erCOD_{sp}$	
$erCOD_k$	total N
	total P
BOD_5	ANA detergents
dissolved O_2	
O_2 saturation	
total alkalinity	
total hardness	

2. Slightly deteriorated components (>3%/year) (n = 6, 22,2%)

Cl^--ion	Na% value
SO_4-ion	amonium-ion
	S-index
total dissolved mater	
sp. conductivity	

3. Significantly deteriorated components (3—7%/year) (n = 6, 22,2%)

Na% value	phenols
pH value	UV oil
PO_4-ion	a-chlorophill

4. Markedly deteriorated components (>7%/year) (n = 1, 3,7%)
   dissolved Mn

Table 3. *Classification of water quality in the Tisza at Szolnok (remark: without UV oil)*

Year	Biol. stab.	Industr. water	Irrig-water	Water used in fishery	Used in drink-ingwater supply
1970.	I.	I.	I.	I.	I.
1971.	I.	I.	I.	I.	I.
1972.	I.	I.	I.	I.	I.
1973.	II.	I.	I.	I.	I.
1974.	II.	I.	I.	I.	I.
1975.	I.	I.	I.	I.	I.
1976.	II.	I.	I.	II.	II.
1977.	I.	I.	I.	I.	I.
1978.	II.	I.	I.	II.	II.
1979.	II.	I.	I.	II.	II.
1980.	II.	I.	I.	II.	II.
1981.	II.	I.	I.	II.	II.
1982.	II.	I.	I.	II.	II.
1983.	II.	I.	I.	II.	II.
1984.	II.	I.	I.	II.	II.
1985.	II.	I.	I.	II.	II.
1986.	II.	I.	I.	I.	I.
1987.	II.	I.	I.	II.	II.
1988.	II.	I.	I.	II.	II.

almost every year the quality of the Tisza water was of II. class and in these respect further deterioration is to be expected.

This is a particulary unfavourable situation, since drinkingwater supply of Szolnok and neighbouring settlements comes from the Tisza.

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A Tisza vízminőségének változása Szolnoknál 1970—1988 között

WAIJANDT J.

KÖTIKÖVIZIG Szolnok Tiszaliget

Kivonat

A Tisza folyót a Sajó torkolatától Szolnokig a tisztulás jellemzi. Szolnoknál jelentős mértékű az ipar és ivóvíz célú vízhasználat, ezért nagy jelentősége van a víz minőségének és hosszabb távú változásának. Elemzésünk során a folyó szolnoki szelvényében (335,4 fkm) heti gyakorisággal 1970—1988 közötti időszakban vett vízminták vizsgálatának eredményeit használtuk fel. A legfontosabb 27 vízminőségi komponenssel foglalkoztunk.

Bemutattuk néhány komponens évenkénti minimum-, maximum- és átlagértékeinek alakulását 1970 és 1988 között. Az átlagértékek által reprezentált vízminőség-változás mértéke nem volt nagy, összességében vízminőségromlás játszódott le. Az 1970—1978 és 1979—1988-as időszakokra vonatkozó regressziós egyenesek felhasználásával meghatároztuk a változások irányát és mértékét. Meg-

állapítható volt, hogy a nagyobb mértékű vízminőségromlás a hetvenes években játszódott le. A vizsgált komponensek 52%-a javuló vagy változatlan minőséget, 22—22%-a kismértékben, ill. nagymértékben romlott 1979 és 1988 között.

Az ipari és öntözővíz céljára a Tisza vize a vizsgálat teljes időszakában I. osztályú volt. A halgazdasági és ivóvíznyerés céljára 1976-tól általában csak II. osztályú minőséggel rendelkezett és ezen vízhasználatok szempontjából a további vízminőségromlásnak van nagyobb valószínűsége.

КАЧЕСТВО ВОДЫ РЕКИ ТИСА В РАЙОНЕ СОЛНОКА В ПЕРИОД 1970—1988

Й. Вайандт

Для отрезка Тисы между устьем Шайо и Солноком характерно улучшение качества воды. Вследствие значительного потребления воды в районе Солнока, используемой в промышленных целях и для снабжения питьевой водой, качество воды и тенденции его изменения в будущем имеют особое значение. В анализе, проведенном автором, использованы результаты измерений на пробах, бравшихся еженедельно на отрезке Тисы у Солнока (335,4 р. км.) в период 1970—1988 гг. Было исследовано 27 наиболее важных характеристик качества воды.

Показано изменение максимальных, минимальных и средних значений нескольких компонентов в период 1970—1988 гг. В этот период не наблюдалось значительных изменений качества воды, судя по средним значениям параметров, в общем произошло ухудшение качества воды. При помощи регрессионных прямых, построенных по данным, полученным в периоды 1970—1978 гг и 1979—1988 гг, были определены степень и направление изменений качества воды. Было установлено, что значительное ухудшение качества воды произошло в 70х годах. Среди исследуемых параметров 52% указывают на улучшение или отсутствие перемен, 22% на незначительное и 22% на значительное ухудшение качества воды.

В течение всего периода наблюдений качество воды Тисы соответствовало I категории в случае использования в промышленности и орошении. Однако, при применении в рыбоводстве и для снабжения питьевой водой с 1976 г. ее качество удовлетворяло требованиям лишь II категории и в этой области ожидается дальнейшее ухудшение.

Kvaliteta vode kod Solnoka u periodu od 1970 do 1988 godine

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Rezime

Drugu najveću reku Mađarske od ušće Šajo do Solnoka očišćenje karakteriše. Kod Solnoka značajna je potrošnja vode i u industrialnom i u građanskom vidu, zato je potrebno pratiti promenu kvaliteta vode i opširne promene. Prilikom analize u odseku dužine (335,4 km, Fig. 1.) nedeljno su vadili primerke u periodu od 1970. do 1988. godine. Analizirani su 27 najvažniji komponenti.

Na 2—5. slicima je prikazan godišnji min., maks. i prosećne krive nekoliko komponenata u periodu od 1970. do 1988. Prosećne krive ne pokazuju veću promenu kvaliteta vode ali u celini kvaliteta se kvario (Tab. 1.). Ovo je dokazano i sa prosećnom koncentracijom, jer su povećali kod više komponenata. Sa metodom regresije odredili su pravac i meru promene za periode 1970—78 i 1979—1988 (Tab. 1.). Veći kvar dogodilo se sedamdesetih. Izučeni komponenti u 52%-u su pokazali poboljšenje ili stagnaciju ali komponenti u 22%-u su pokazali manje ili veće kvarenje u periodu od 1979 do 1988 god. (Tab. 2.) Prema industrijalnim i meliorizacionim kriterijumima voda Tise je bila I klasa preko celog izučenog perioda (Tab. 3.). Za dobivanje vode za ribolovarstvo i za potrošnju građana kvaliteta vode ja bila II klasa od 1976. god. I dalje se može očekivati kvarenje kvaliteta vode.